LAB LOCATION

UNDER CONSTRUCTION

SAMPLING AND TESTING

Aggregate sampling for obtaining **minimum** sample sizes shall be in accordance with Sample Method use of larger samples should be considered by the QC staff to increase the probability of obtaining a respective sample. When split samples are required by the provision, the field sample size shown in the CMM needs to be doubled.

Sampling During Production Or Post-Production

For the production or post-production sampling required by the provision, the contractor can obtain samples from the finished product conveyor belt or stockpile. Obtaining samples from the belt discharge is acceptable if the full production stream can be obtained with sufficient rapidity and safety.

Selection of random sample locations shall be in accordance with the QMP provision.

Sampling During Placement

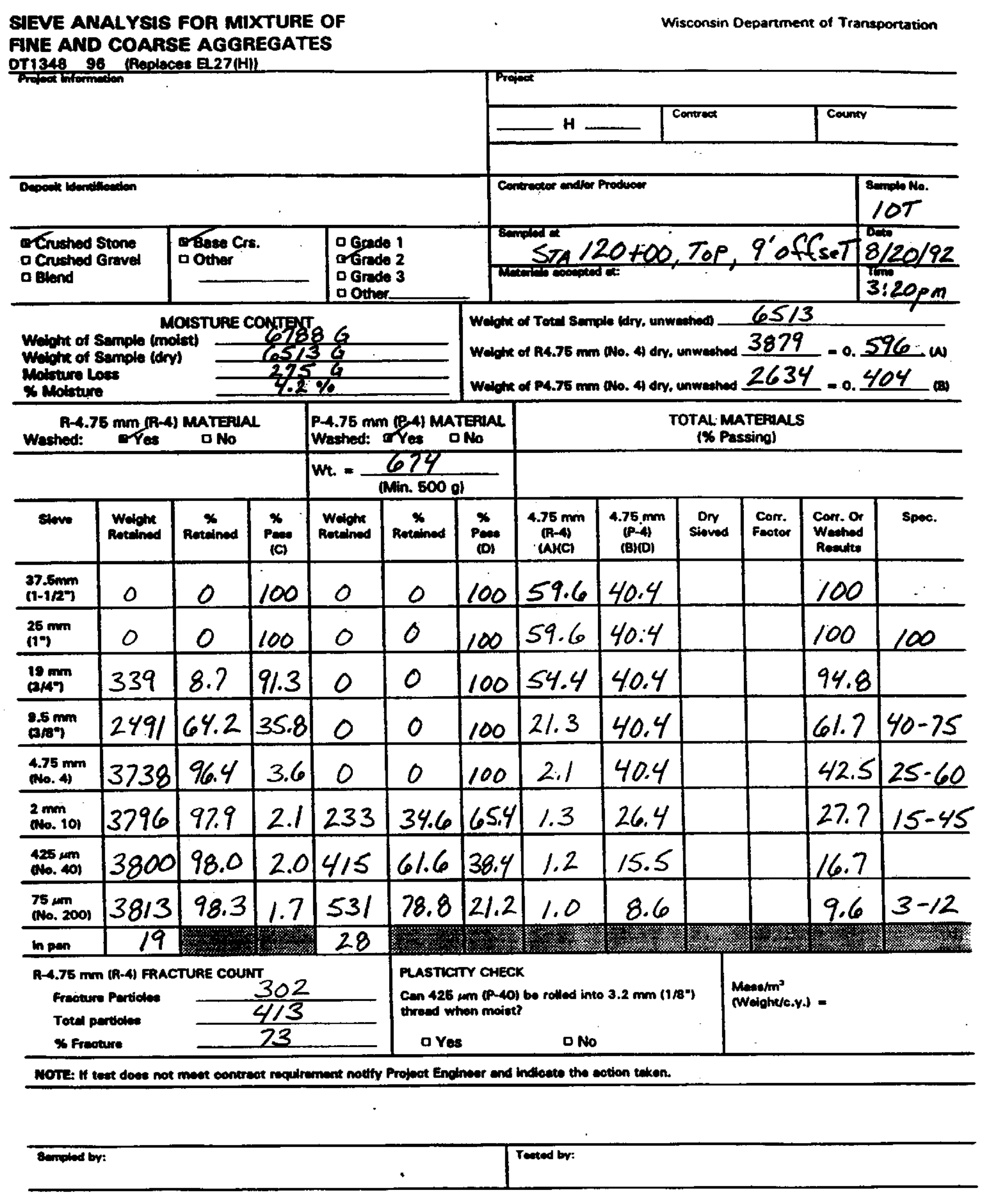
Sampling from the roadbed shall be performed according to the provision. Sampling shall take place after blading and shaping but prior to initiating compaction. The intent is to obtain samples as near to the final placement location of the material as possible so as to truly represent the aggregate placed. Sampling from roadbed windrows should only be used when the subgrade is granular and it would not be possible to differentiate the change in material between the crushed aggregate base course and the granular subgrade.

The quantity of materials for roadbed field sampling should be doubled since samples are needed for both Quality Control and Department testing according to special provision requirements of the contract.

Sieve Analysis

The sample weights derived from procedure 2-20 are **minimums**. As has been pointed out for field sample sizes, the use of larger samples should be given careful consideration by the QC staff to increase the probability of obtaining a representative sample. Sieve analysis testing shall follow AASHTO T 11 and T

27 as modified in the CMM. Test data and calculation results should be recorded on a copy of **Sieve Analysis for Mixture of Fine and Coarse Aggregates, Form DT1348**. For consistency throughout the testing operations it is preferred the test mass be made in units of grams. **Figure 1** is an example of a completed test data sheet for a typical sample of aggregate base course material.



SIEVE ANALYSIS FOR MIXTURE OF FINE AND COARSE AGGREGATES
DT1348 96 (Replaces EL27(H))

Wisconsin Department of Transportation

Project Information

Project: ____ H ____ Contract County

Deposit Identification

Contractor and/or Producer

Sample No. 10T

☑ Crushed Stone ☐ Crushed Gravel ☐ Blend

☑ Base Crs. ☐ Other ______

☐ Grade 1 ☑ Grade 2 ☐ Grade 3 ☐ Other______

Sampled at: STA 120+00, TOP, 9' offseT

Date: 8/20/92

Materials accepted at:

Time: 3:20pm

MOISTURE CONTENT
Weight of Sample (moist) 6788 G
Weight of Sample (dry) 6513 G
Moisture Loss 275 G
% Moisture 4.2 %

Weight of Total Sample (dry, unwashed) 6513
Weight of R4.75 mm (No. 4) dry, unwashed 3879 = 0. 596 (A)
Weight of P4.75 mm (No. 4) dry, unwashed 2634 = 0. 404 (B)

R-4.75 mm (R-4) MATERIAL Washed: ☑ Yes ☐ No

P-4.75 mm (P-4) MATERIAL Washed: ☑ Yes ☐ No
Wt. = 674 (Min. 500 g)

TOTAL MATERIALS (% Passing)

Sieve	Weight Retained	% Retained	% Pass (C)	Weight Retained	% Retained	% Pass (D)	4.75 mm (R-4) (A)(C)	4.75 mm (P-4) (B)(D)	Dry Sieved	Corr. Factor	Corr. Or Washed Results	Spec.
37.5mm (1-1/2")	0	0	100	0	0	100	59.6	40.4			100	
25 mm (1")	0	0	100	0	0	100	59.6	40.4			100	100
19 mm (3/4")	339	8.7	91.3	0	0	100	54.4	40.4			94.8	
9.5 mm (3/8")	2491	64.2	35.8	0	0	100	21.3	40.4			61.7	40-75
4.75 mm (No. 4)	3738	96.4	3.6	0	0	100	2.1	40.4			42.5	25-60
2 mm (No. 10)	3796	97.9	2.1	233	34.6	65.4	1.3	26.4			27.7	15-45
425 µm (No. 40)	3800	98.0	2.0	415	61.6	38.4	1.2	15.5			16.7	
75 µm (No. 200)	3813	98.3	1.7	531	78.8	21.2	1.0	8.6			9.6	3-12
In pan	19			28								

R-4.75 mm (R-4) FRACTURE COUNT
Fracture Particles 302
Total particles 413
% Fracture 73

PLASTICITY CHECK
Can 425 µm (P-40) be rolled into 3.2 mm (1/8") thread when moist?
☐ Yes ☐ No

Mass/m³ (Weight/c.y.) =

NOTE: If test does not meet contract requirement notify Project Engineer and indicate the action taken.

Sampled by: Tested by:

Figure 1

Sieve Analysis for Mixture of Fine and Coarse Aggregates

DT1328

Sieve Analysis for Mixture of Fine and Coarse Aggregates DT1348

WS3015 - Running Average Calculations, is a generic sheet that may be used to calculate running average values for the aggregate gradation sieve fractions. **WS3017 Aggregate Gradation Control Charts**, may be reproduced for plotting aggregate sieve fractions.

Running Average Calculations WS3015

Aggregate Gradation Control Charts WS3017

Gradation of aggregate should be expressed in percent passing sieve sizes. Separate charts shall be kept for 2", 1-1/2", 1", 3/4", 1/2", 3/8", #4, #8, #10, #16, #30, #40 #50, #100 and #200 (50mm, 37.5mm, 25mm, 19mm, 12.5mm, 9.5mm, 4.75mm, 2.36mm, 2.00mm, 1.18mm, 600μm, 425μm, 300μm, 150μm and 75μm). Control charts for only the sieve sizes specified by the applicable specification need to be produced.

Permeability Test

The contractor may choose to sample and test Base Aggregate Open Graded for permeability rather than aggregate gradation during placement. The sample is obtained in the same manner as a sample collected for gradation testing. Permeability testing shall be performed according to the procedure. The permeameter shall be constructed in accordance with the detailed drawings of Appendix A. Test data should be recorded on a copy of **WS3100 – Base Aggregate Open Graded Permeability Test Data**. **Figure 2** is an example of the permeability test data form completed for a typical sample of Base Aggregate Open Graded.

Base Aggregate Open Graded Permeability Test Data WS3100

Fractured Particle Count

Fractured particle testing shall be according to Procedure 4-25-50 of the CMM Manual. Test data may be recorded on a copy of **WS3100** as shown in **Figure 2**. The Qc tester should complete the test form by making the required calculation. Fractured Particle test results shall be plotted on a control chart. The tester may use **WS3019 Base Aggregate Fractured Particle Control Chart**, for reproduction as needed.

Base Aggregate Fractured Particle Control Chart WS3019

DEPARTMENT TESTING

Verification and independent assurance sampling and testing will be performed by the Department or a Department representative as described in the provision.

Verification Testing

Verification testing will be performed by an HTCP certified department representative on samples collected independently of the contractor's samples. Testing of the material will be conducted in a separate laboratory and with separate equipment from the contractor's tests.

For verification testing, three separate samples will be collected. Each of the three samples will be collected from three adjacent 100 foot (40 meter) long roadway sections. The sample location in each section will be randomly selected. These samples will be kept separate and each will be large enough to perform the necessary verification tests.

OPEN GRADED BASE COURSE, NUMBER 2
PERMEABILITY TEST DATA

PROJECT DESCRIPTION		SAMPLE INFORMATION	
Project ID.	Contract	Material Source	
Highway	County	Material (Type, Grade, Etc.)	
Description		Tested By:	
Contractor		Date Sampled:	

Sample Number: 714R-10 Time: 9:00 am

Sampling Location: Station: 165+00 Offset: 6 ft. lft.

Dry Density: 101.5 lbs/cu ft Target Unit Weight: 8.7 lbs.

Test No.	Test Time (Sec.) T_1	T_2	T_3	Test Time Average (Sec.) T_{ave}	Permeability (Ft/day) K_n	
1	14.2	15.3	14.8	14.8	5838	K_1
2	16.0	14.1	15.4	15.2	5684	K_2
3	14.6	14.0	13.1	13.9	6216	K_3
				$K_{ave} = (K_1 + K_2 + K_3)/3 =$	5913	

Fractured Particle Count (Retained on No. 4 Sieve)
Number of Aggregate Particles in Sample = 413 = (T)
Number of Aggregate Particles with at Least One Fractured Face = 302 = (F)
Fractured Particles, % by Count = - (100) = 302/413 (100)) = 73 %

Comments: ______

Sample Number: 714R-11 Time: 11:05 am

Sampling Location: Station: 420+90 Offset: 8 ft. rt.

Dry Density: 111.7 lbs/cu. ft. Target Unit Weight: 9.61 lbs.

Test No.	Test Time (Sec.) T_1	T_2	T_3	Test Time Average (Sec.) T_{ave}	Permeability (Ft/day) K_n	
1	15.0	16.0	15.5	15.5	5574	K_1
2	15.6	15.8	15.9	15.8	5468	K_2
3	16.2	15.8	16.0	16.0	5400	K_3
				$K_{ave} = (K_1 + K_2 + K_3)/3 =$	5481	

Fractured Particle Count (Retained on No. 4 Sieve)
Number of Aggregate Particles in Sample = ______ = (T)
Number of Aggregate Particles with at Least One Fractured Face = ______ = (F)
Fractured Particles, % by Count = - (100) = ______ (100)) = ______ %

Comments: ______

Figure 2.2 Attachment 7

Figure 2
Base Aggregate Open Graded
Permeability Test Data

Independent Assurance Review

Independent assurance reviews will be conducted by a Department representative in accordance with the provision and the Department's Independent Assurance Program. These reviews will be made of the contractor's Quality Control and the Department's Verification sampling and testing equipment and personnel.

DISPUTE RESOLUTION

Dispute resolution will be conducted according to the provision. The split samples of the material collected for Qc testing can be used to help resolve conflicts. The use of these samples will be as agreed to by the contractor and the Department.

AGGREGATE FOR CONCRETE PAVEMENT

General

Details of the procedures used to meet the requirements of the QMP, Aggregate for Concrete Pavement provision are presented in the following subsections.

Sampling

Aggregate sampling for obtaining **minimum** sample. The use of larger samples should be considered by the Qc staff to increase the probability of obtaining a respective sample.

For the aggregate sampling required by the provision, the contractor can obtain samples from the finished product conveyor belt, holding bins, or stockpile. Obtaining samples from the belt discharge is excellent if the full production stream can be obtained with sufficient rapidity and safety.

Selection of random sample location shall be in accordance with the QMP provision.

Testing

Aggregate Sieve Analysis

The methods and frequencies for aggregate gradation sampling and testing shall be according to the QMP provision.

The QMP provision allows for a portion of the gradation testing of course aggregates to be performed with an unwashed method. The procedures for unwashed (dry) sieve analysis are identical to those for washed (wet) sieve analysis except for references to washing operations. The processes for washed or unwashed sieve analysis testing shall follow AASHTO T 11 and AASHTO T 27 as modified by WisDOT. Be aware that it is necessary to grade (sieve) all individual samples of both fine and coarse aggregates through the coarse and fine sieve series. Test data shall be recorded on a copy of **WS5015 Sieve Analysis for Concrete Aggregate**, as shown in **Figure 3**.

Sieve Analysis for Concrete Aggregate WS5015

The sieve analysis test data sheet, and all subsequent use of the data should clearly indicate whether washed or unwashed testing was used. The tester shall refer to CMM Procedure 4-25-50 for instructions to determine whether dry sieving is acceptable or if wet sieving is required. While the QMP special provisions specify only every 10th sample of coarse aggregate is to be subjected to a washed analysis, the intention is that a dry analysis should be used only if it will provide reliable data. If, when comparing test results, sieve analysis comparisons are marginal or P/200 is above the warning limit, a washed sieve analysis shall be performed on each sample until results by washed sieving meet the criteria.

Fineness Modulus

The fineness modulus of fine aggregate is required to be calculated by the special provision and is intended to be for information only. Fineness modulus shall be calculated for the fine aggregate as outlined below. Data and calculations should be recorded on a copy of **WS5015 Sieve Analysis for Concrete Aggregate**, as shown in **Figure 3**.

SIEVE ANALYSIS FOR CONCRETE AGGREGATE

PROJECT DESCRIPTION		SAMPLE INFORMATION	
Project ID.	Contract	Material Source	
Highway	County	Material (Type, Grade, Etc.) Fine, Conc. Agg.	
Description		Sampled By:	
Contractor		Date Sampled: 5/11/98	Time: 10:00 am
		Tonnage @ Sampling 5000	Sample No. 511-02-F

MOISTURE CONTENT:

$$\text{Percent Moisture} = \frac{W_S - D_W}{D_W - T}(100) = \frac{(730 - 705)}{(705 - 215)}(100) = \underline{\quad 5.1 \quad}\%$$

T = Weight of Container

Ww = Weight of Container + Wet Sample Weight

Dw = Weight of Container + Dry Sample Weight

SIEVE ANALYSIS: Dry, Unwashed Total Sample

Washed: ____ Unwashed: X Weight, gms: 515

Fine: X Coarse #1: ____ Coarse #2: ____

SIEVE	Wt. Ret'd, gms.	% Ret'd	% Pass	SPECIFICATIONS Fine	C.A. #1	C.A. #2
2" (50 mm)						
1 1/2" (37.5 mm)						
1" (25 mm)						
3/4" (19 mm)						
3/8" (9.5 mm)	0	0.0	100.0	100		
#4 (4.75 mm)	15	2.9	97.1	90 - 100		
#8 (2.36 mm)	97	18.8	81.2			
#16 (1.16 mm)	218	42.3	57.7	45 - 80		
#30 (0.6 mm)	308	59.8	40.2			
#50 (0.3 mm)	423	82.1	17.9	10 - 30		
#100 (0.15 mm)	498	96.7	3.3	2 - 10		
#200 (0.075 mm)	510	99.0	1.0	0 - 1.5		
Wt in Pan =	5					

FINENESS MODULUS (Fine Aggregate):

$$\text{Fineness Modulus} = \frac{\Sigma \text{total \% Ret'd on: \#4, \#8, \#16, \#30, \#50, \#100}}{100}$$

$$= (3 + 19 + 42 + 60 + 82 + 97)/100 = 3.03$$

Remarks:

Figure 3.1 Attachment 10

Figure 3

Sieve Analysis for Concrete Aggregate

Fineness modulus is determined by adding the total percentages of material by weight retained on sieve Nos. 4, 8, 16, 30, 50 and 100 (4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm) then dividing by 100.

For example:

Sieve No.	Spec. Percent Passing	Sample Percent Passing	Sample Percent Retained
4 (4.75mm)	90-100	98	2
8 (2.36mm)		80	20
16 (1.18mm)	45-80	60	40
30 (600µm)		32	68
50 (300µm)	10-30	20	80
100 (150µm)	2-10	8	92
		Total =	302

Fineness Modulus = 302/100 = 3.02

Corrective Action

Corrective Action shall be implemented according to the provision.

Department Testing

Quality verification and independent assurance sampling and testing will be performed by the Department or a Department representative as described in the provision. Sampling and testing will be performed by a Certified Technician.

Verification Testing

Verification testing will be performed by an HTCP certified department representative on samples collected independently of the contractor's samples. Testing of the material will be conducted in a separate laboratory and with separate equipment from the contractor's tests.

With this provision, the contractor has two options for when the department's Quality Verification testing will be performed on the aggregate for concrete pavement. For option 1, Quality Verification testing is performed at the time of production. For option 2, Quality Verification testing is performed at the time the aggregate is being used or relocated. Regardless of which option is used, the contractor is responsible for the product after it has been sampled, tested and accepted. Minimal segregation, contamination, and degradation shall occur with relocation of the material. The engineer may require additional sampling and testing at the concrete plant site and use a statistically based Pooled T-Test to evaluate whether the quality of the material has been maintained. Follow procedure for the Pooled T-Test.

Independent Assurance Review

Independent assurance reviews will be conducted by a Department representative in accordance with the provision and the Department's Independent Assurance Program. These reviews will be made of the contractor's Quality Control and the department's verification sampling and testing equipment and personnel.

Dispute Resolution

Dispute resolution will be conducted according to the provision. ✶

APPENDIX A

PERMEABILITY APPARATUS AND PROCEDURE

WISCONSIN DOT

FALLING HEAD PERMEAMETER TEST
for
INDEX PERMEABILITY OF OPEN GRADED BASES
(October 1994)

1.0 SCOPE

This method describes test procedures and related equipment to determine the Index Permeability of open graded base courses. This test is not suitable for soils or dense graded base courses.

2.0 GENERAL

The testing procedures and equipment described in this document are based on the current practices utilized by the WisDOT Product Quality Management Section to determine the Index Permeability (Kn) of open graded base course material. Both the testing procedures and equipment are modifications of the New Jersey Falling Head Permeability Test For Open Graded Materials. This test is not approved by either AASHTO or ASTM. However, the test will determine a repeatable value of " Kn".

3.0 APPARATUS

3.1 Mold. A 12 3/16 inch (31.0 cm + .02 cm) high metal mold with an inside diameter of 4.0 inches (10.2 cm + .2 cm) and a minimum wall thickness of .25 inch (.63 cm + .03 cm) shall be used to contain the sample. A #16 (1.18 mm) sieve shall be securely fastened to the base of the mold in such a manner that it will not restrict the inside diameter of the mold. The top of the mold shall be machined to a depth of 3/16 inches (.50 cm + .02 cm) and a minimum inside diameter of 4.25 inches (10.8 cm + .02 cm) to accept the standpipe. See attached drawings.

3.2 Standpipe. A section of clear plastic pipe with a minimum length of 24 inches (61 cm) and a maximum inside diameter of 4.0 inches (10.2 cm + .02 cm) shall be used as a water standpipe. The base of the standpipe shall be machined to a depth of 3/16 inches (.50 cm + .02 cm) and a maximum diameter of 4.25 inches (10.8 cm + .02 cm) to fit to the top of the steel mold. The standpipe shall be clearly marked with a circumferential line located at a distance of 21.3 inches (54.1 cm) above the top of the steel mold when the mold and standpipe are fitted together. See attached drawings.

3.3 Support Stand. A support stand with a trap door valve shall be constructed to support the filled mold and standpipe. The trap door valve shall form an essentially water-tight seal against the base of the mold and shall be designed for an instantaneous release. No part of the stand or the trap door valve when open shall create an impedance to water flow through the mold. See attached drawings for details.

3.4 Water Supply. A supply of clear potable water capable of filling the standpipe in less than 60 seconds shall be available.

3.5 Stopwatch. A stopwatch capable of measuring up to 30 minutes with an accuracy of 0.1 seconds shall be used to conduct this test.

4.0 TEST PROCEDURES

4.1 Form a representative sample of the material to be tested determine a mass equal to 8.6% of the Target Unit Weight (mass) of the material. The Target Unit Weight (mass) is defined as the unit weight (mass) which is achieved when the material is compacted at 6% moisture content in accordance with the methods and procedures contained in AASHTO T-99, Method C. The test mold shall be placed on a flat unyielding surface and secured in place. The obtained sample of material shall be brought to 6% moisture content and shall be compacted in the mold in three layers of approximately equal thickness. Each layer shall be compacted by at least 20 but no more than 25 blows from a drop hammer with a mass of 5.5 lbs. (2500 gms) and a drop height of 12 inches (30.5 cm). The final compacted height (D) of the sample in the mold shall not be less than 11.5 inches (29 cm) or more than 12 inches (30 cm). The standpipe shall be fitted to the mold and the joint shall be treated with petroleum jelly, silicone gel, latex caulking, or other similar materials to achieve a water tight connection. The assembled mold and standpipe shall be placed on the support base and stand assembly and shall be securely fixed in a vertical position. The trap door valve shall be closed and an essentially water tight seal shall be achieved. The stand pipe shall then be filled with water to the circumferential fine located 21.3 inches (54.1 cm) above the top of the mold. The test shall be started by simultaneously opening the trap door valve and activating the stopwatch. Timing shall continue until the water level reaches the top of the mold. If the required water drop has not occurred within 30 minutes from the start of the test, the test shall be terminated and the sample shall be ruled unacceptable. The elapsed time (T_n) shall be noted and recorded to the nearest 0.1 seconds. The test shall be repeated two additional times without disturbing the apparatus or the sample.

4.2 Calculation of Permeability (K). The 3 time values (T_1, T_2, T_3) determined by the testing shall be averaged and recorded to the nearest 0.1 second as (T_{ave}). The

Falling Head Index Permeability (K_n) shall be calculated as follows:

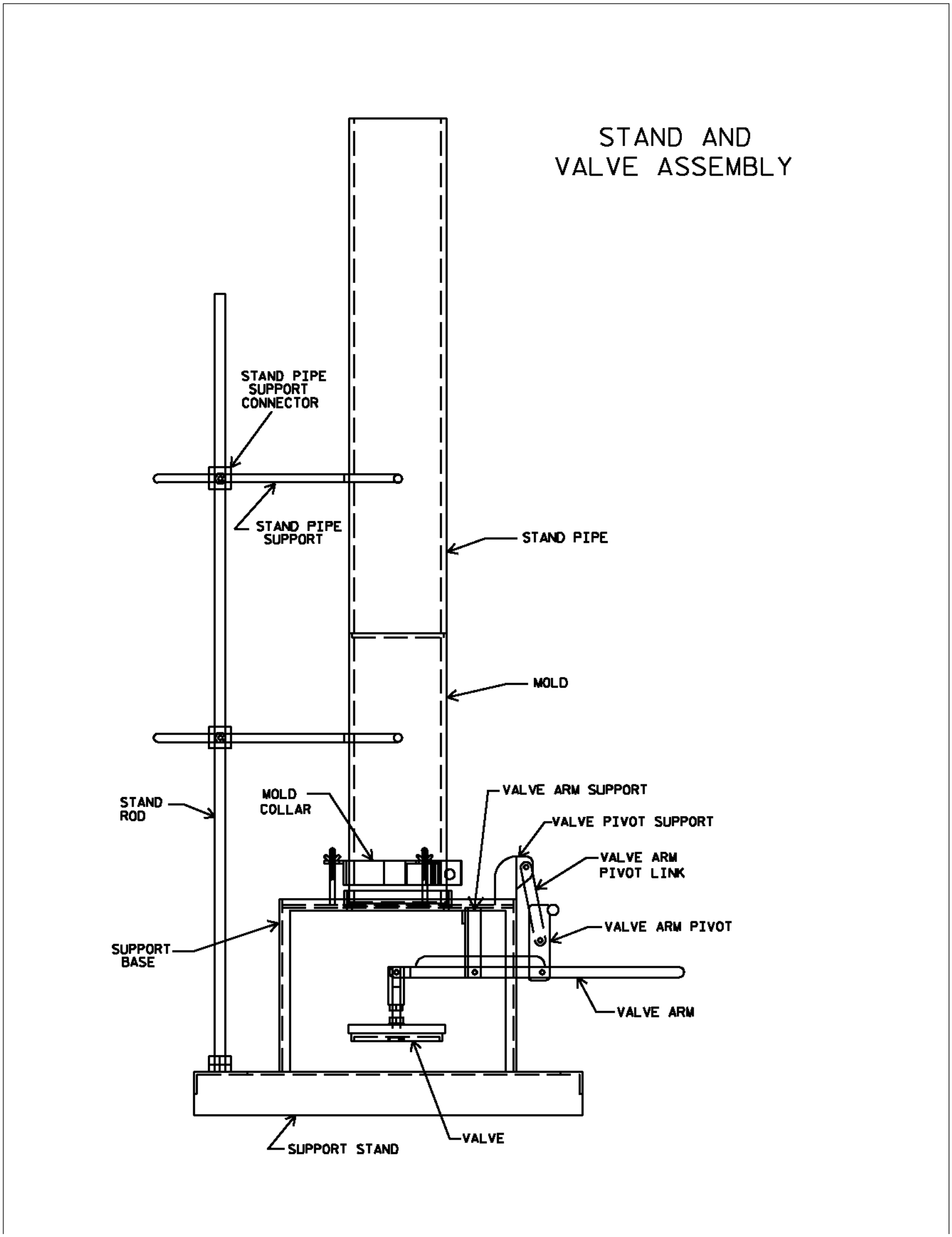
$$K_n \text{ (ft/day)} = 7200\,(D) / T_{ave}$$

Where: ***D*** is the final compacted height of the sample in inches and T_{ave} in seconds.

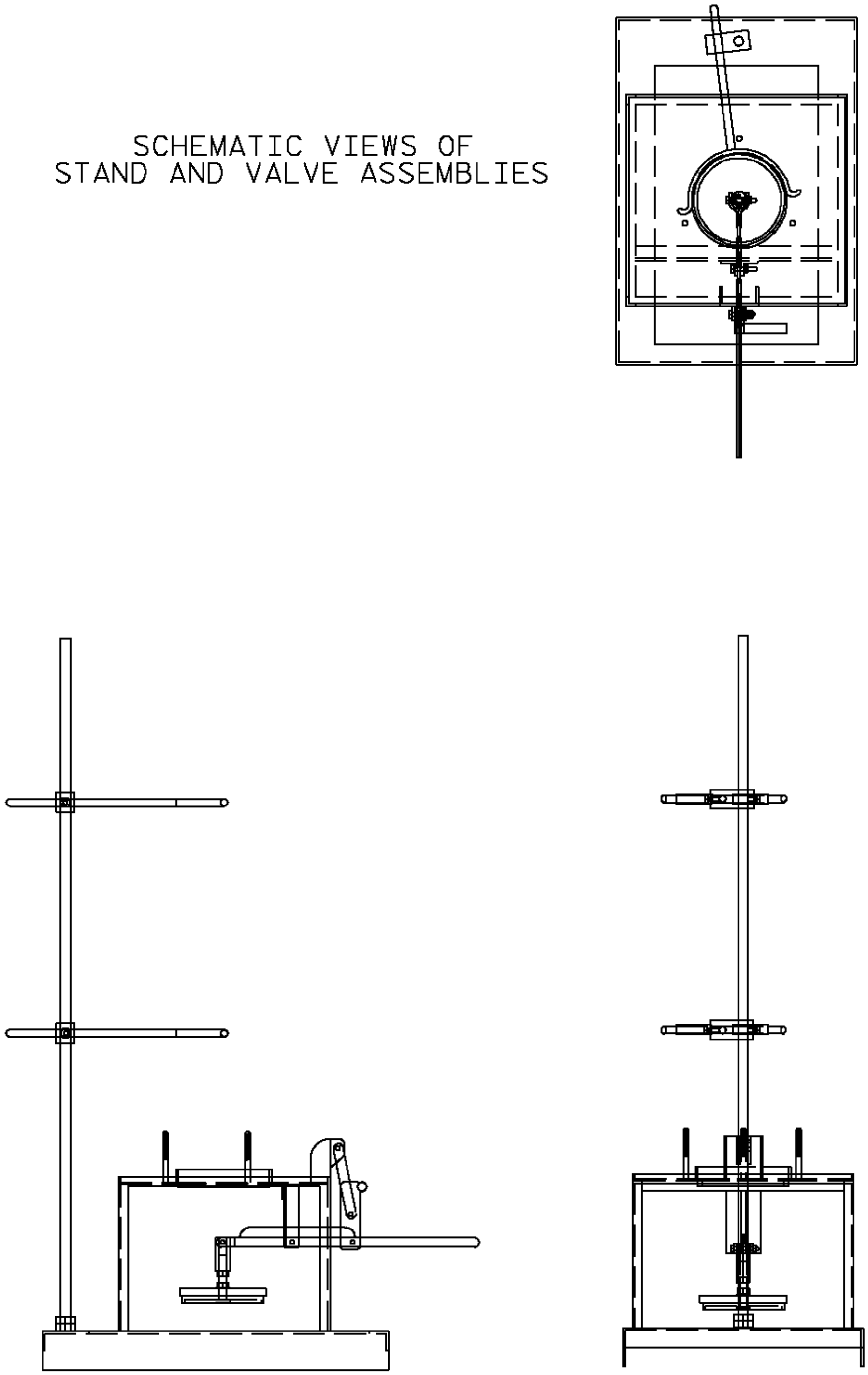
$$K_n \text{ (cm/sec)} = (D) / T_{ave}$$

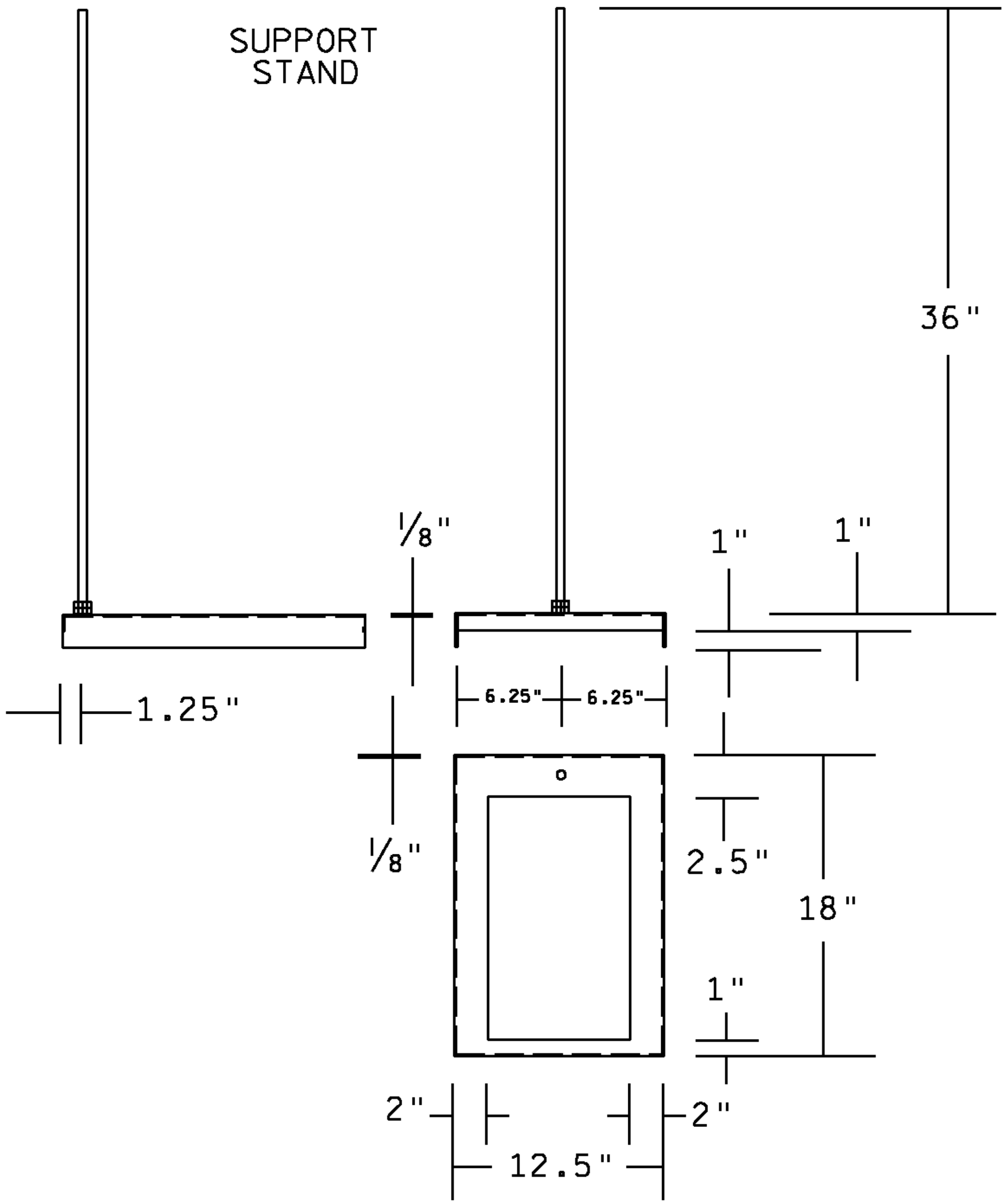
Where: ***D*** is the final compacted height of the sample in centimeters and T_{ave} is in seconds.

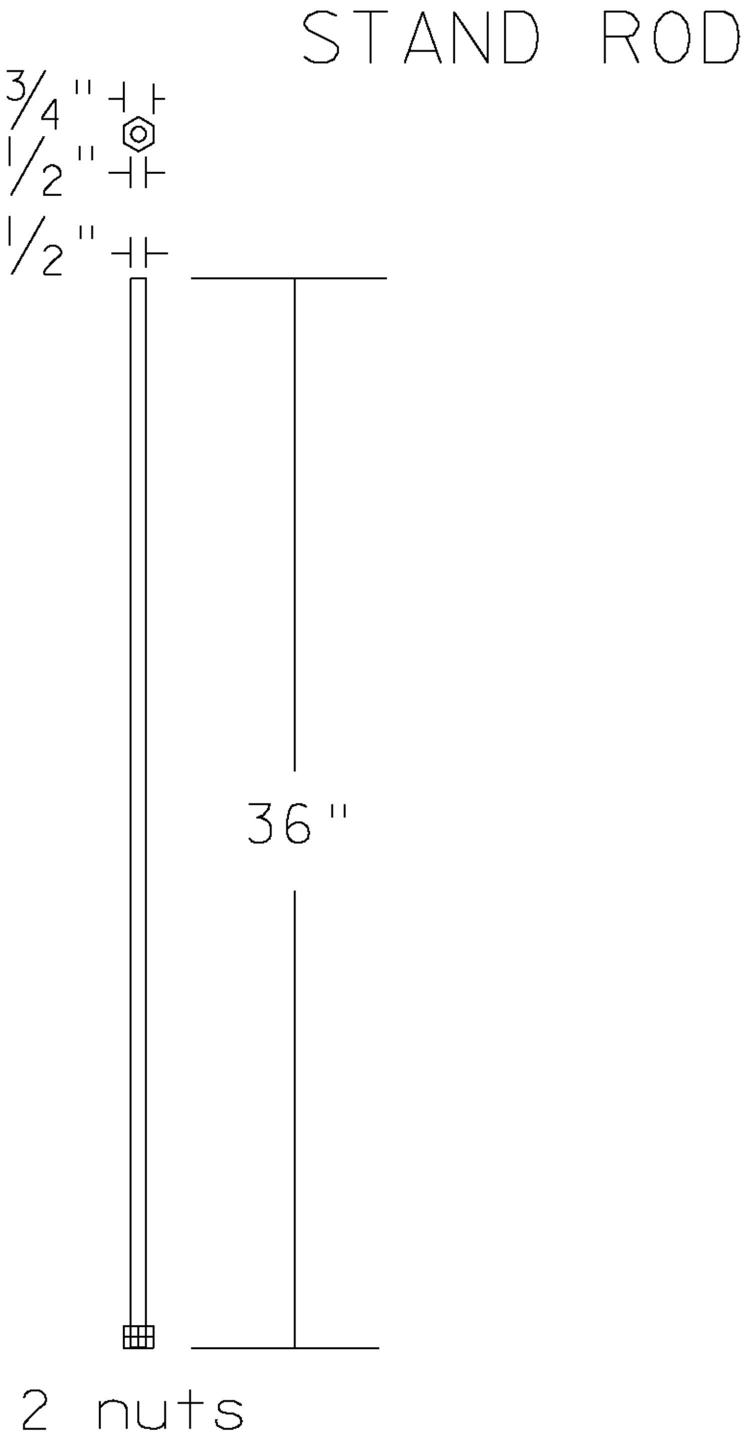
4.3 Reporting. Three different samples shall be tested following this procedure. This procedure requires that the test be run three times on each sample to obtain three time values (T_1, T_2, and T_3) that are averaged to calculate a T_{ave} for each sample. The individual sample permeability (K_1 K_2, and K_3) can be calculated knowing D and T_{ave}. K_{ave} is the average value of K_1 K_2, and K_3 and is the value plotted on the control chart. Also report the Target Unit Weight (mass), as defined in 4.1 of test procedures, of sample placed in the mold.


STAND AND
VALVE ASSEMBLY
STAND PIPE
SUPPORT
CONNECTOR
STAND PIPE
SUPPORT
STAND PIPE
MOLD
VALVE ARM SUPPORT
STAND
ROD
MOLD
COLLAR
VALVE PIVOT SUPPORT
VALVE ARM
PIVOT LINK
VALVE ARM PIVOT
SUPPORT
BASE
VALVE ARM
SUPPORT STAND
VALVE

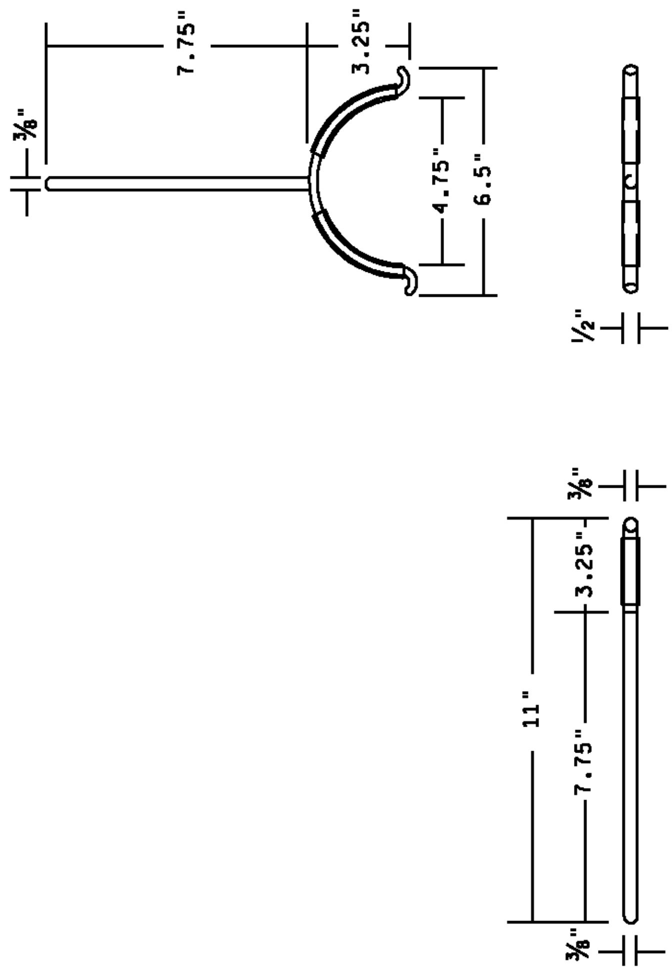
SCHEMATIC VIEWS OF
STAND AND VALVE ASSEMBLIES



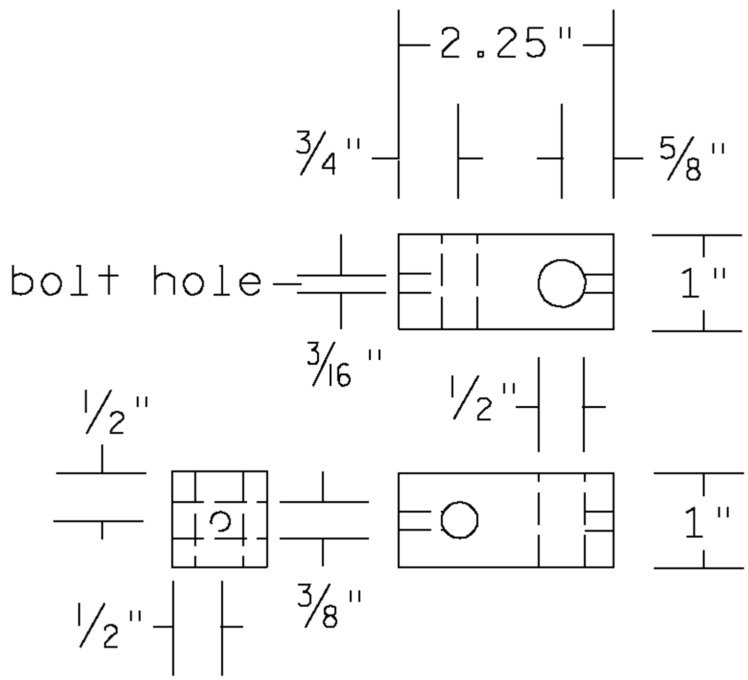

SUPPORT
STAND
36"
1/8"
1"
1"
1.25"
6.25"
6.25"
1/8"
2.5"
18"
1"
2"
2"
12.5"

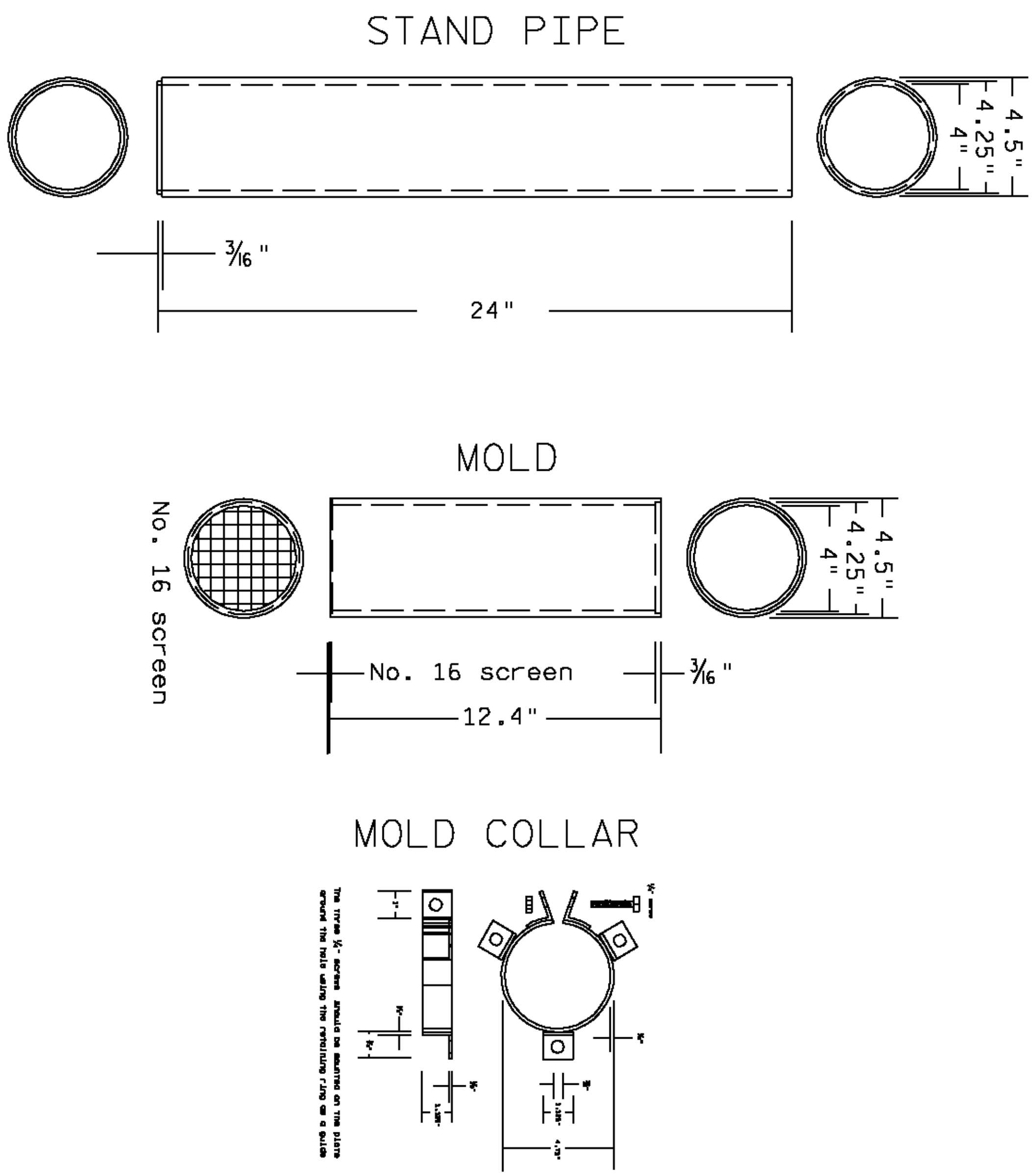

STAND ROD
3/4"
1/2"
1/2"
36"
2 nuts

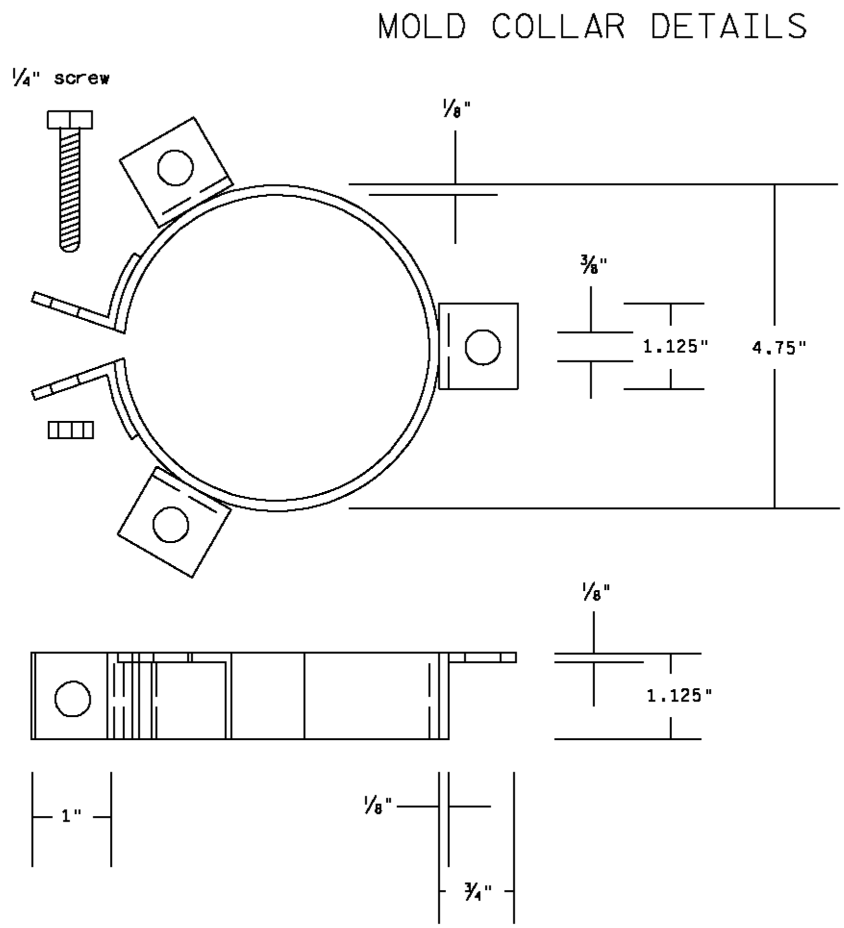
STAND PIPE SUPPORTS



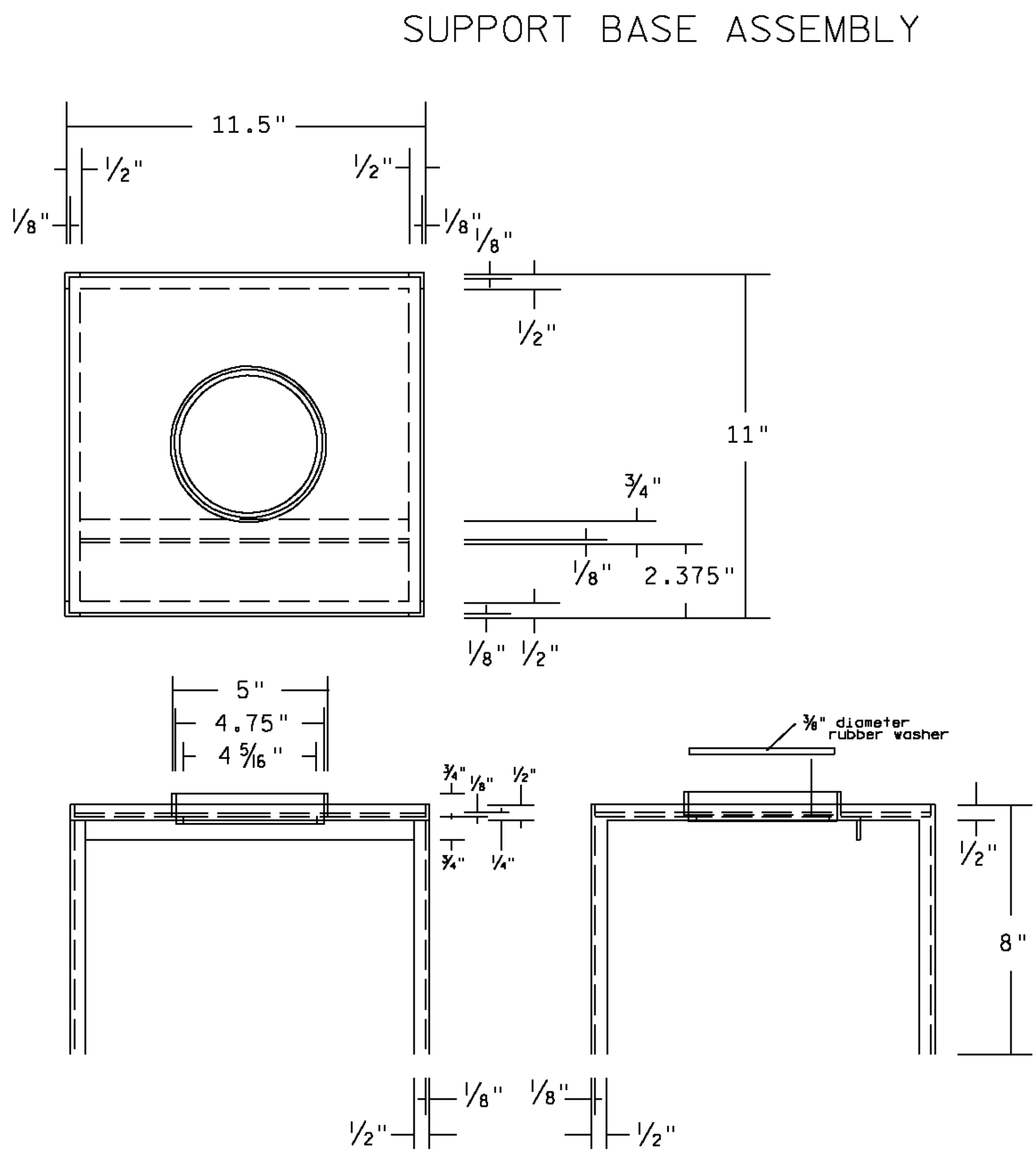
STAND PIPE SUPPORT CONNECTORS



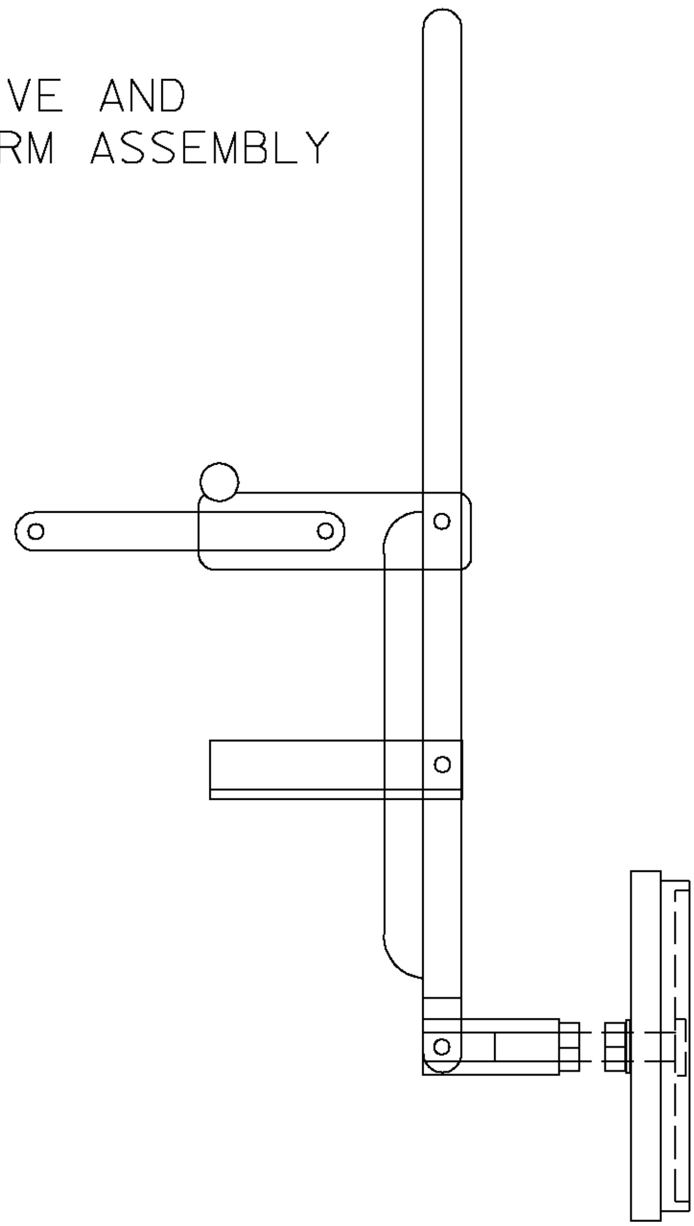

STAND PIPE
4.5"
4.25"
4"
3⁄16"
24"
MOLD
No. 16 screen
4.5"
4.25"
4"
No. 16 screen
3⁄16"
12.4"
MOLD COLLAR



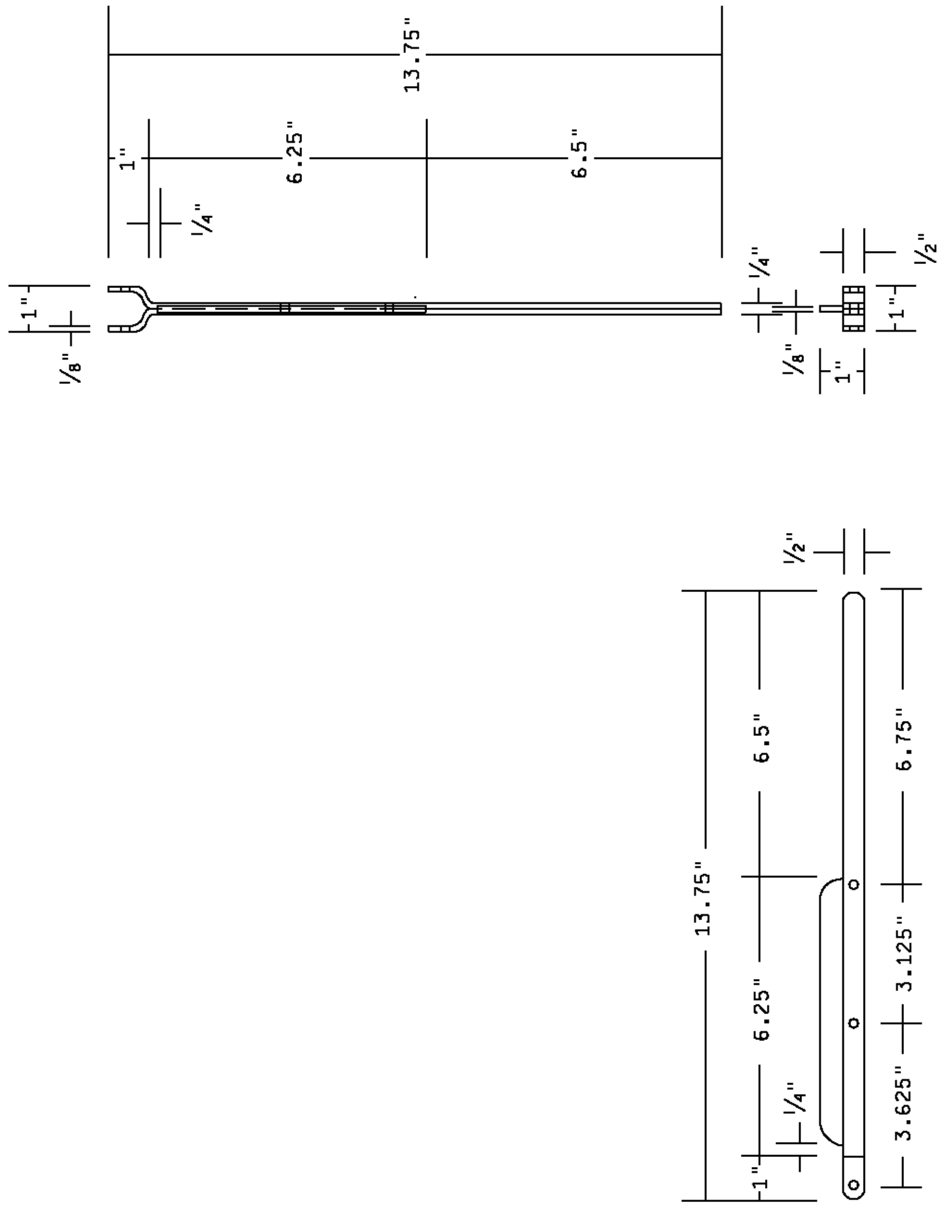
The three 1/4" screws should be mounted on the plate around the hole using the retaining ring as a guide

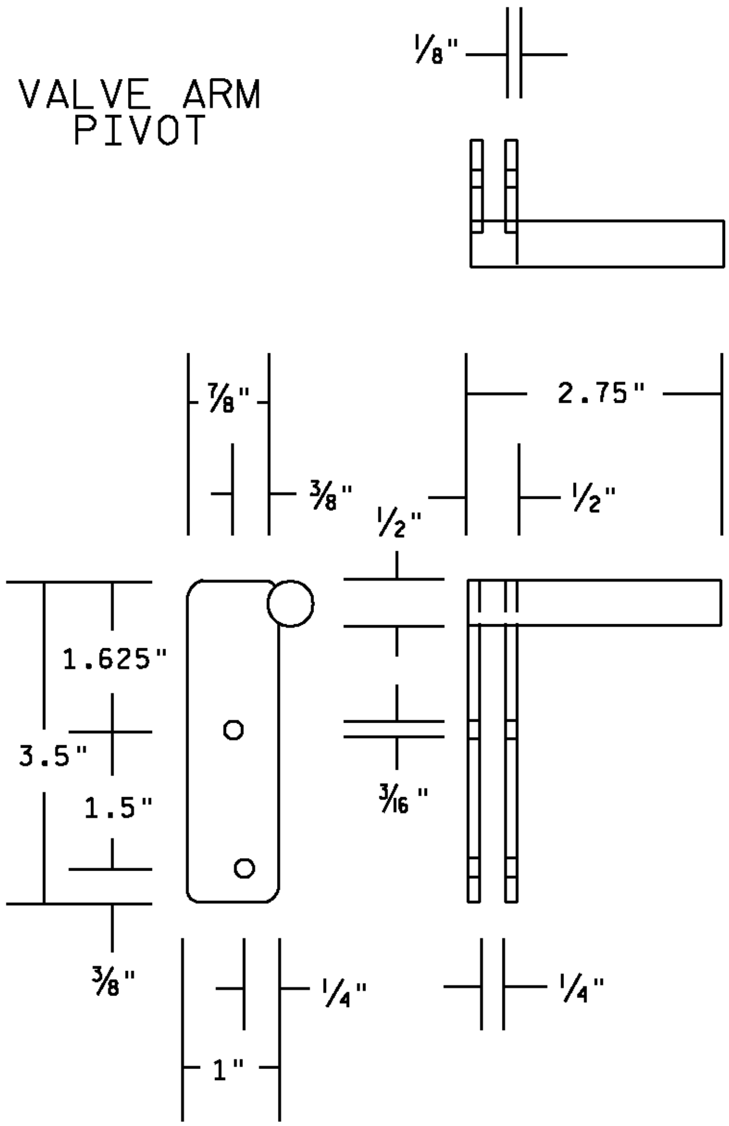

SUPPORT BASE ASSEMBLY
11.5"
1/2"
1/2"
1/8"
1/8"
1/8"
1/2"
11"
3/4"
1/8"
2.375"
1/8"
1/2"
5"
4.75"
4 5/16"
3/4"
1/8"
1/2"
3/4"
1/4"
3/8" diameter rubber washer
1/2"
8"
1/8"
1/8"
1/2"
1/2"

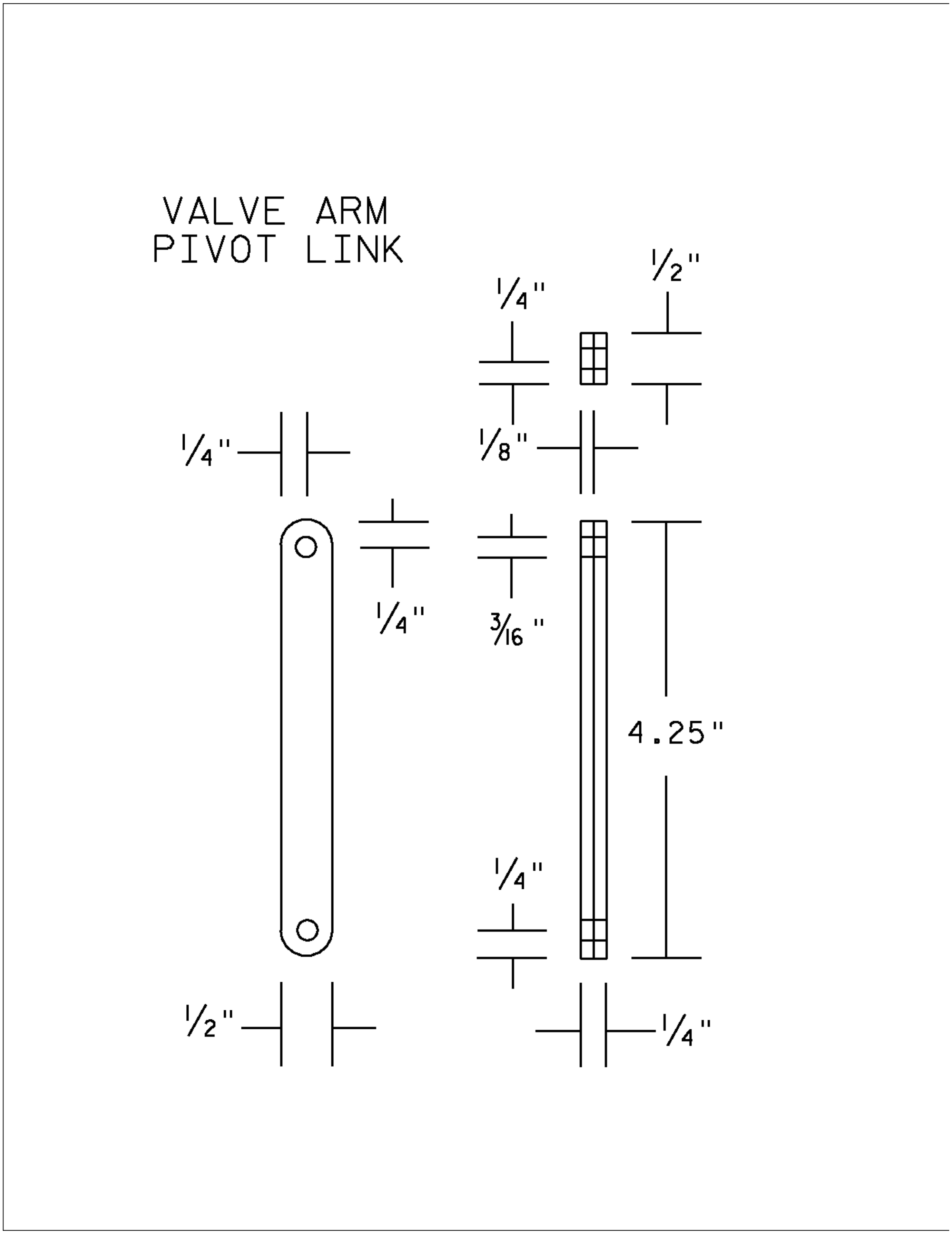
VALVE AND
VALVE ARM ASSEMBLY



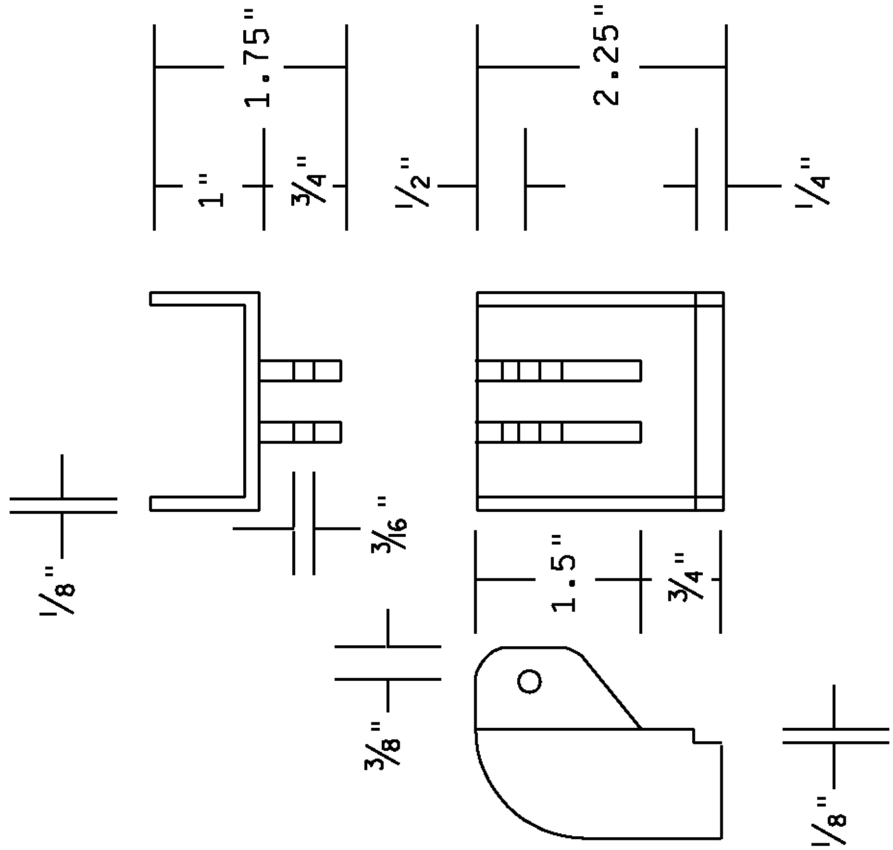
VALVE ARM

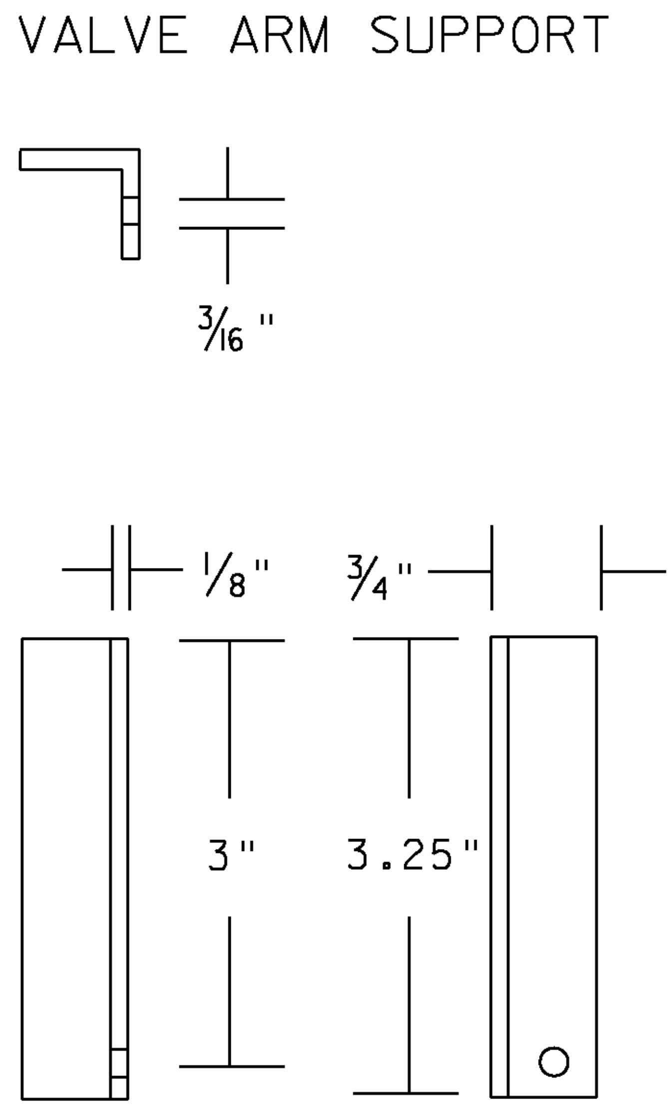


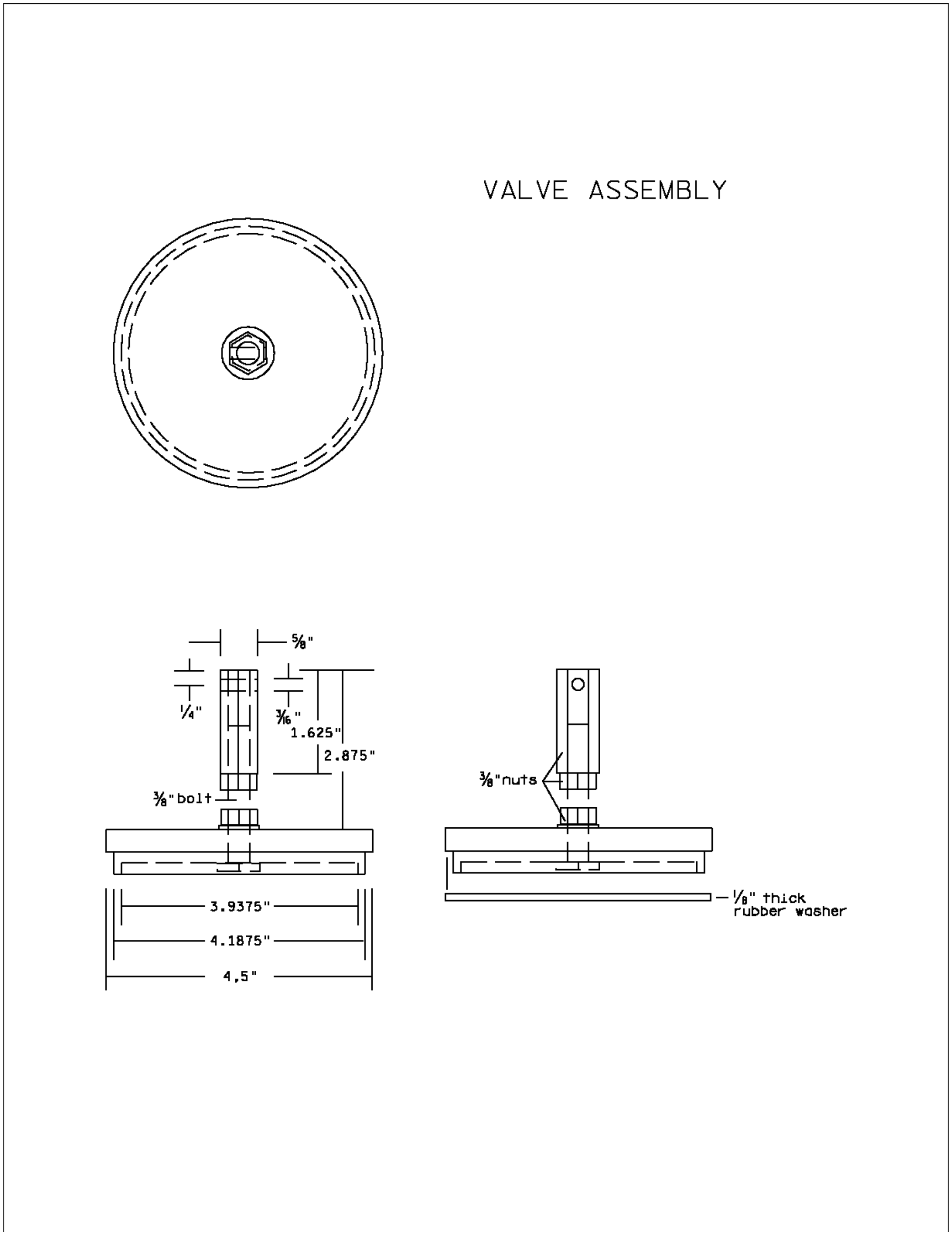

VALVE ARM
PIVOT
⅛"
⅞"
⅜"
2.75"
½"
½"
1.625"
3.5"
1.5"
3⁄16"
⅜"
¼"
¼"
1"


VALVE ARM
PIVOT LINK
1/2"
1/4"
1/4"
1/8"
1/4"
3/16"
4.25"
1/4"
1/2"
1/4"

VALVE PIVOT SUPPORT




VALVE ARM SUPPORT
3/16"
1/8"
3/4"
3"
3.25"


VALVE ASSEMBLY
5/8"
1/4"
3/16"
1.625"
2.875"
3/8" bolt
3/8" nuts
3.9375"
4.1875"
4.5"
1/8" thick
rubber washer

APPENDIX B

POOLED T-TEST PROCEDURE

POOLED t-test

The pooled t-test is a statistically based procedure to evaluate the variability in the mean (average) of test results between 2 sets of data. When QMP, Aggregate for Concrete Pavement is specified and the contractor chooses option 1, in the special provision, the contractor's test results tabulated from the sieve analysis for gradation may be evaluated and compared to the engineer's test results of the relocated aggregate, if the aggregate is relocated. This procedure will only apply to those contracts where the aggregate is produced at one location then moved to a new location. This procedure is a tool that may be used to compare the test results mean of the original stockpile (contractor's data) to the test results mean of the relocated stockpile (engineer's data). A failed comparison between the original aggregate and the relocated aggregate may be the result of segregation, contamination or degradation which occurred in the relocation/restockpiling process. The engineer will make the final determination on the quality of the material.

On the following pages a step-by-step procedure illustrates how to compute the F statistic, which you will then compare to the CRITICAL VALUES FOR F DISTRIBUTION (F critical table provided). If the F critical is greater than the F statistic you computed you are sure with a 99 percent confidence level that the relocated stockpile is the same as the original stockpile.

> NOTE: The minimum number of tests required on the relocated stockpile is 5 tests or 20 percent, which ever is greater, of the tests taken on the original stockpile. Therefore, if 77 tests are taken on the original stockpile you need to take at least 15 tests on the relocated stockpile.

A sample calculation of the F statistic is provided and a comparison is made to the F critical. In the example provided, the pooled t-test confirms that the stockpiles are the same.

POOLED t-TEST PROCEDURE
(One-Way Analysis of Variance)

1.) Calculate Average Test Results (A) for each stockpile:

$A1 = \Sigma\sigma 1 / n1$ $\quad$ $A2 = \Sigma\sigma 2 / n2$

σ : the individual test result

n : the number of tests performed on that stockpile

1 : original stockpile

2 : moved stockpile

2.) Calculate the Grand Mean (T) for Pooled Data:

$T = (\Sigma\sigma 1 + \Sigma\sigma 2) / (n1 + n2)$

3.) Calculate the Treatments Sum of Squares (SST):

$SST = n_1 ((A_1 - T)^2) + n_2 ((A_2 - T)^2)$

4.) Calculate the Error Sum of Squares (SSE):

$$SSE = \sum_{1}^{n_1} (\sigma_1 - A_1)^2 + \sum_{2}^{n_2} (\sigma_2 - A_2)^2$$

5.) Calculate the Treatments Mean Square (MST) & Error MeanSquare (MSE):

$MST = SST / 1$ $\quad$ $MSE = SSE / ((n_1 - 1) + (n_2 - 1))$

6.) Calculate the F-Statistic (F):

$F = MST / MSE$

7.) Determine the Critical F-Statistic (F critical):

Look this value up in a F Distribution Table using 1% probability values
Numerator Degrees of Freedom = 1
Denominator Degrees of Freedom = (n1 -1) + (n 2 - 1)

8.) Compare F-Statistics:

If F < F critical then the stockpiles are the same
If F > F critical then the stockpiles are not the same

CRITICAL VALUES FOR F DISTRIBUTION

(1% Probability Values & 1 Degree of Freedom)

Degrees of Freedom for Denominator	F critical
1	40.52
2	98.49
3	34.12
4	21.20
5	16.26
6	13.74
7	12.25
8	11.26
9	10.56
10	10.04
11	9.65
12	9.33
13	9.07
14	8.86
15	8.68
16	8.53
17	8.40
18	8.28
19	8.18
20	8.10
21	8.02
22	7.94
23	7.88
24	7.82
25	7.77
26	7.72
27	7.68
28	7.64
29	7.60
30	7.56
32	7.50
34	7.44
36	7.39
38	7.35
40	7.31
42	7.27
44	7.24
46	7.21
48	7.19
50	7.17
55	7.12
60	7.08
65	7.04
70	7.01
80	6.95
100	6.90

EXAMPLE: POOLED T-TEST CALCULATION

1. A_1 = (60+58+52+59+56+64+65+51+61+57+59+62+60+64+63) /15 = **59.33**

   A_2 = (54+63+58+51+49) /5 = **55.00**

2. T = (60+58+52+59+56+63+65+51+61+57+59+62+60+64+63+54+63+58+51+49) / (15+5) = **58.25**

3. SST = 5 ((55.00 - 58.25)^2) + 15 ((59.33 - 58.25)^2) = **70.31**

4. SSE = 233.35 + 126 = **359.35**

60 - 59.33 = 0.67	$(0.67)^2$ = 0.45
58 - 59.33 = -1.33	$(-1.33)^2$ = 1.77
52 - 59.33 = -7.33	$(-7.33)^2$ = 53.73
59 - 59.33 = -0.33	$(-0.33)^2$ = 0.11
56 - 59.33 = -3.33	$(-3.33)^2$ = 11.09
63 - 59.33 = 3.67	$(3.67)^2$ = 13.47
65 - 59.33 = 5.67	$(5.67)^2$ = 32.15
51 - 59.33 = -8.33	$(-8.33)^2$ = 69.39
61 - 59.33 = 1.67	$(1.67)^2$ = 2.79
57 - 59.33 = -2.33	$(-2.33)^2$ = 5.43
59 - 59.33 = -0.33	$(-0.33)^2$ = 0.11
62 - 59.33 = 2.67	$(2.67)^2$ = 7.13
60 - 59.33 = 0.67	$(0.67)^2$ = 0.45
64 - 59.33 = 4.67	$(4.67)^2$ = 21.81
63 - 59.33 = 3.67	$(3.67)^2$ = 13.47
	Total = **233.35**

54 - 55 = -1	$(-1)^2$ = 1
63 - 55 = 8	$(8)^2$ = 64
58 - 55 = 3	$(3)^2$ =9
51 - 55 = -4	$(-4)^2$ = 16
49 - 55 = -6	$(-6)^2$ = 36
	Total = 126

5. MST = 70.31/ 1 = **70.31**

   MSE = 359.35 / ((15 - 1) + (5 - 1)) = **19.96**

6. F Statistic = 70.31 / 19.96 = **3.52**

7. F Critical = **8.28** (DF = 18 for denominator)

8. F Statistic = 3.52 < F Critical = 8.28

   Stockpiles are the same.